Use of Simulation Learning Experiences in Physical Therapy Entry-to-Practice Curricula: A Systematic Review

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ABSTRACT

Purpose: To review the literature on simulation-based learning experiences and to examine their potential to have a positive impact on physiotherapy (PT) learners' knowledge, skills, and attitudes in entry-to-practice curricula. **Method:** A systematic literature search was conducted in the MEDLINE, CINAHL, Embase Classic+Embase, Scopus, and Web of Science databases, using keywords such as *physical therapy*, *simulation*, *education*, and *students*. **Results:** A total of 820 abstracts were screened, and 23 articles were included in the systematic review. While there were few randomized controlled trials with validated outcome measures, some discoveries about simulation can positively affect the design of the PT entry-to-practice curricula. Using simulators to provide specific output feedback can help students learn specific skills. Computer simulations can also augment students' learning experience. Human simulation experiences in managing the acute patient in the ICU are well received by students, positively influence their confidence, and decrease their anxiety. There is evidence that simulated learning environments can replace a portion of a full-time 4-week clinical rotation without impairing learning. **Conclusions:** Simulation-based learning activities are being effectively incorporated into PT curricula. More rigorously designed experimental studies that include a cost-benefit analysis are necessary to help curriculum developers make informed choices in curriculum design.

Key Words: education; patient simulation; physical therapy specialty; students; systematic review.

RÉSUMÉ

Objectif : Examiner les publications sur les expériences d'apprentissage par la simulation afin de déterminer si ces expériences peuvent avoir un effet positif sur les connaissances, l'attitude et les compétences des étudiants en physiothérapie dans un programme de formation au niveau débutant. **Méthode :** Une recherche systématique a été effectuée dans les publications des bases de données MEDLINE, CINAHL, Embase Classic+Embase, Scopus et Web of Science, à l'aide des mots-clés tels *physiothérapie*, *simulation*, *éducation* et *étudiants*. **Résultats :** Un total de 820 résumés ont été examinés et 23 articles ont été inclus dans l'examen systématique. Bien qu'il y ait eu peu d'essais contrôlés randomisés avec des mesures de résultats validées, certaines découvertes au sujet de la simulation peuvent avoir un effet positif sur la conception des programmes de formation au niveau débutant en physiothérapie. L'utilisation de simulateurs pour fournir des données de rétroaction précises peut aider les étudiants à acquérir des compétences spécifiques. Les logiciels de simulation peuvent également optimiser l'expérience d'apprentissage des étudiants. Les expériences de simulation humaine pour la gestion des patients en soins de courte durée dans une unité de soins intensifs sont reçues favorablement par les étudiants, leur donnent plus d'assurance et diminuent leur anxiété. Des preuves portent à conclure que les environnements d'apprentissage simulés peuvent remplacer une partie d'une rotation clinique de 4 semaines à temps plein sans nuire à l'apprentissage. **Conclusions :** Les activités d'apprentissage par la simulation sont incorporées efficacement aux programmes de physiothérapie. Des études expérimentales plus rigoureuses comprenant une analyse coûts-avantages devront être effectuées pour aider les concepteurs à prendre des décisions éclairées en matière d'élaboration de programmes d'études.

Simulation learning experiences (SLEs) have been used extensively in professional education. Maran and Glavin have provided an overview, focusing on medical education, on the variety of simulation experiences, as well as the role of simulation in assessment and learning.¹ The concepts covered in their article can reasonably be transferred to other health professional education programmes. The concept of *fidelity* has been defined as the extent to which the appearance and behaviour of

the simulator/simulation matches the appearance and behaviour of the simulated system.¹ The concept of fidelity has been further elaborated to include *engineering fidelity* (the degree to which a simulation replicates physical characteristics) and *psychological fidelity* (the critical elements to accurately simulate specific behaviours).² Thus, this concept of simulation fidelity includes a range of experiences from simulation of real-time changes in vital signs, with several invasive and non-

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invasive monitoring and interventional devices attached (e.g., tracheal ventilation), through to simple simulations of a clinical task, such as paper case studies or simple cardboard-box models that replicate surgical procedures.¹ For an educator selecting SLEs, it is important to consider the most appropriate simulation experience for the learner, as well as what aspects of the task will be the focus during learning. Less complicated simulations may be most appropriate for novice students learning basic skills, whereas more advanced learners can benefit from more complex simulations.³ Studies have also explored the progressive use of simulation to maximize learning,⁴ whereby gradual changes in simulator attributes are introduced as the student's ability improves. The overall goal of SLEs is to allow an opportunity for deliberate practice; learning is measured as the sustained improvements in performance that are observed after a rest period following the end of practice.⁵

The several existing reviews on simulation and effective learning^{2,6–9} have focused on SLEs in medicine. A recent scoping review on simulation-augmented education in the rehabilitation professions included multiple rehabilitation professions as well as pre- and post-licensure learning.¹⁰ Our systematic review, therefore, was designed to summarize the literature on the use of SLEs in physical therapy and to address the following research question: Can SLEs be meaningfully incorporated in physical therapy (PT) entry-to-practice curricula to positively affect learners' knowledge, skills, and attitudes?

Our literature search was geared toward finding articles that included PT learners; that examined an SLE and compared it to standard curriculum delivery practice (although articles with no comparator were also accepted); that assessed the intervention on a range of outcomes, from satisfaction to behaviour change; and whose study design included, at minimum, a post-test design. Standardized patients (SPs), also known as simulated patients, are often used for assessing students as well as teaching communication and interpersonal skills, especially in undergraduate curricula,¹ and studies of SP account for a vast proportion of the simulation literature. For the purposes of this systematic review, we chose to focus on simulation studies that expanded beyond using SPs to teach communication and interpersonal skills; therefore, our search included studies with a focus on attainment of technical skills, clinical case management, and clinical experiences.

METHODS

Data sources and searches

To address the research question, we systematically searched five databases: MEDLINE (1946–October week 1, 2013, including in-process and other non-indexed citations); CINAHL (1981–October 11, 2013); Embase Classic+Embase (1947–week 41, 2013); Scopus (all years,

Table 1 MEDLINE Literature Search Strategy: Ovid MEDLINE (1946–October week 1, 2013), Ovid MEDLINE In-Process and Other Non-Indexed Citations (October 1, 2013), completed on October 11, 2013

#	Searches	Results
1	Programmed Instruction as Topic/	2,433
2	Computer-Assisted Instruction/	9,464
3	Computer Simulation/	147,525
4	Patient Simulation/	3,121
5	User-Computer Interface/	30,639
6	simulat\$.mp.	386,090
7	(standardi\$ adj patient\$).mp.	1,991
8	(computer\$ adj model\$).mp.	8,039
9	Manikins/	3,016
10	mannequin\$.tw.	942
11	manikin\$.tw.	1,572
12	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	425,745
13	exp Physical Therapy Modalities/	124,050
14	Physical Therapist Assistants/	0
15	exp Physical Therapy Specialty/	2,146
16	exp Physical Therapists/	285
17	(physical adj therap\$).tw.	13,589
18	physiotherap\$.tw.	15,204
19	physio-therap\$.tw.	42
20	13 or 14 or 15 or 16 or 17 or 18 or 19	139,510
21	exp Teaching/	67,243
22	Education/	18,574
23	Educational Measurement/	27,905
24	Learning/	46,482
25	Students/	34,498
26	Preceptorship/	3,959
27	Curriculum/	57,805
28	21 or 22 or 23 or 24 or 25 or 26 or 27	216,781
29	12 and 20	2,411
30	28 and 29	173
31	limit 30 to English language	164

all subject areas, up to October 11, 2013); and Web of Science (all years, all subject areas, up to October 11, 2013). We performed three sub-searches—one on simulation, the second on physical therapy, and the third on students and education—which were then combined to identify the abstracts from each database. An example of the comprehensive search performed in MEDLINE, and the results it produced, is shown in Table 1. Searches were limited to the English language.

Study selection

We included abstracts of original research with a full paper (excluding dissertations and conference proceedings) in which the participants included student physiotherapy learners, the intervention included an SLE,

and the intervention was assessed (including participant satisfaction with the learning experience and objective educational assessment measures such as standardized outcome measures). For the purpose of abstract review, we defined *simulation* as the range of learning experiences (e.g., role playing) in which the learner had the opportunity to interact with the simulated clinical scenario. We did not include simulation studies that involved no interaction between the learner and the educational media (e.g., watching a DVD or an online learning module in which the learner only had to click “Next” to advance through the screens) or those that focused on simulation experiences as a form of learner assessment. Two calibration trials were completed between two authors (BM, JH) to ensure that we were applying the inclusion criteria consistently and to identify any potential sources of bias.

Data extraction and quality assessment

One reviewer (BM) extracted data from all included studies; a second reviewer (JH) checked the data for accuracy. We then summarized the purpose, research design, time span, participants, simulation experience, outcomes, results, and conclusions of each selected study in a table. In addition, we rated the quality of each article using the MERSQI instrument,¹¹ which consists of 10 items in 6 domains of study quality (study design, sampling, type of data, validity, data analysis, and outcomes). If a domain is not applicable, no score is attributed to that item. The maximum score for each domain is 3, for a maximum potential score of 18.

RESULTS

Data synthesis and analysis

We identified 164 abstracts from MEDLINE, 136 from CINAHL, 436 from EMBASE, 113 from Scopus, and 222 from Web of Science. After removal of duplicates, 820 abstracts remained. Figure 1 is a flow diagram depicting the steps to identify the included articles. The first author (BM) reviewed all citations; 752 were excluded for not meeting the inclusion criteria. The remaining 68 abstracts were then reviewed by two authors (BM, JH); 8 were excluded based on the inclusion criteria (descriptive only (2); publication was a PhD dissertation, and no article based on it was available as yet (1); computer-administered instruction with no learner interactivity (2); simulation as a form of assessment (1); content was not applicable to our question (2)), and 60 full-text articles were then retrieved. Of these, 38 were excluded, for reasons listed in Figure 1. One additional article was retrieved from the reference list of an included article that did not appear in any of the database searches, for a final total of 23 articles included in the systematic review.

Data extracted from the articles and MERSQI ratings can be found in Appendix 1 online. We grouped the articles into four clusters, which we discuss below.

Group A: Simulation activities for learning specific skills (8 studies)

Eight articles focused on using simulation learning strategies for learning specific skills. Five studies examined simulation models to facilitate skill development in manual therapy mobilizations, four of which focused on performing a posterior–anterior (PA) lumbar spine mobilization^{12–16} while the fifth simulated glenohumeral joint mobilization. In these studies, a simulator was used to quantify the mobilization forces by measuring the mean force exerted by the student through the plinth onto a force plate. Three studies used human participants who received the mobilization,^{12,14,15} two used mechanical simulators.^{13,16} These studies found that using concurrent or terminal feedback provided by the simulator helped PT learners to apply more accurate and consistent force during mobilizations^{12–16} with less variability;¹² results were maintained 5 days¹³ and 1 week after the intervention.¹⁴ Only one study examined the long-term retention of the manual therapy skills, which was poor at 3-month follow-up.¹⁵

Another study used a simulator to provide feedback to PT students learning to administer therapeutic ultrasound (US).¹⁷ When the simulator provided feedback (mean pressure from the US head), the experimental group was able to provide more uniform and appropriate pressure, but these results were not maintained 7 months later. Similarly, in a study that used a simulator mechanism to provide feedback via a pressure manometer for peak airway pressures during manual hyperinflation on a test lung, the availability of feedback produced significant improvement in accuracy and variability, but once the feedback from the simulator was removed, even within 10 minutes, the improvements were no longer observed.¹⁸

Following training with a preterm infant simulator, one study¹⁹ demonstrated a drastic improvement in the skill of percussing the simulated preterm infant (3% pre-instruction vs. 97% post-instruction). After 5 months, students who had participated in the simulation learning experience demonstrated better recall of key components of the technique on a follow-up questionnaire than those who had not.

Most of these studies had small sample sizes (ranging from 9 students in an experimental group¹⁶ to 37 students¹⁹); their MERSQI scores ranged from 11/15 to 12.5/15, with the exception of one that scored 11.5/18.¹⁹ Nevertheless, these studies do seem to indicate that using simulators to provide feedback during learning confers an advantage in skill development; however, the benefits of the learning achieved with the simulator do not persist at long-term follow-up (beyond 1 week).

Group B: Interactive computer games or programmed simulation learning activities (3 studies)

Three of the included studies used a computer game or a programmed interface as the SLE.^{20–22} One study

Figure 1 Study selection flow chart.

explored the effect of the Aging Game on allied health students' level of anxiety about aging and attitudes toward aging.²⁰ The Aging Game is a simulation learning activity that attempts to change attitudes and improve empathy toward older adults by having participants experience functional changes such as loss of hearing,

vision, and mobility.^{20,23} Students were assessed by two validated outcome measures as well as a completing a questionnaire that elicited socio-demographic information and also asked about their experiences with older adults. The students generally had low levels of anxiety about aging and positive attitudes toward older adults

before the simulation experience; while the overall changes in their anxiety and attitudes were small, most reported less anxiety and more positive attitudes regarding aging.

The other two studies in this group used Second Life (Linden Lab, San Francisco, <http://secondlife.com>), a three-dimensional virtual world in which players can construct and interact with their unique environment, as the SLE.^{21,22} In the first, a virtual home environment was constructed to allow PT and occupational therapy students to conduct a home assessment, identify environmental barriers and supports, and then make decisions about environmental task modifications.²¹ Based on their simulated experience, students produced an assignment focusing on three functional, task-specific goals; they demonstrated a high level of decision making in at least three of the four assignment criteria. In addition, students felt that the simulated home environment facilitated their decision making, was realistic, and would enable them to apply their learning to an actual home assessment.²¹ The second study used Second Life to facilitate an inter-professional student case discussion; 60% of participants agreed or strongly agreed that this was an effective method of conducting the small-group learning session, identifying convenience, flexibility, and real-time discussions, as well as the interactive nature of the experience, as the major advantages. Technical issues were the most commonly reported challenge.²²

It is important to note that all of these studies had low MERSQI scores (ranging from 7.5/18 to 12.5/18). None had a control group, only one²⁰ used validated outcome measures, and only one²¹ assessed learning as well as student satisfaction. At present, it appears that simulation activities in the form of computer games or programmed interfaces can augment students' learning experience and may be less time intensive for students; however, there can be increased costs to faculty in terms of designing the programmes, providing technical assistance, or moderating discussion groups if required.

Group C: Simulation for managing a case presentation (5 studies)

Five of the included studies used human simulation experiences to enhance the learning experience for managing a patient in the acute-care environment. Four used high-fidelity human simulation (HFHS);^{24–27} the fifth used a student to role-play a patient in the neurological intensive care unit (ICU).²⁸

Using a crossover design, one study examined students' ability to make clinical decisions based on electrocardiographic (ECG) interpretation using human patient simulation (HPS) compared with a standardized patient with ECG strips.²⁴ While there were no significant differences between groups in their management of the patient based on patient presentation or on the ECG strips, students did indicate a strong preference for the HPS or for a combined HPS and standardized patient

learning experience: the HPS allowed the students to see changes in patient response/signs, and they liked seeing the rhythms on the monitor rather than on paper strips.

A second study²⁵ used a one-group pretest–posttest design to assess PT students' performance of technical skills (assessing bed mobility and respiratory status), behavioural (communication) skills, and cognitive skills (recognizing a change in status and responding), as well as their confidence and satisfaction, in managing a patient in ICU using an HFHS. Following the SLE, students reported improved confidence in technical and behavioural performance measures, with large to very large effect sizes for cognitive–behavioural measures, and 98% agreed that the SLE was valuable. Because of the self-reported increase in confidence, the authors hypothesized that a positive introduction to the critical care environment may increase interest in working in that area, citing anecdotal reports that physical therapists feel uncomfortable and inadequately prepared to work in a high-risk environment such as the ICU.

The remaining three studies^{26–28} were single-group post-intervention studies with non-validated outcomes, and consequently scored very low on the MERSQI tool. Two studies used an HFHS;^{26,27} the third²⁸ used a student to role-play a patient in the ICU, with monitoring lines and tubes (e.g., peripheral IV, subdural intracranial pressure sensor) taped to the student. All three studies found a self-reported decrease in anxiety, improved confidence in managing the patient in ICU, and high satisfaction with the learning experience.

There are clear advantages to using human simulation learning experiences to facilitate students' development of the skills and reasoning required to manage a patient in the ICU. Allowing students to practise these skills in a safe environment appears to improve their confidence and decrease their anxiety, and may enable them to work more effectively in the ICU, a potentially intimidating environment. However, these advantages come with a cost. Only two of the five studies^{25,27} hinted at a cost estimate for the HFHS learning experience; one reported that the mannequin used cost \$35,000, while the other estimated an average cost of \$50,000—and the mannequin is only one component of the costs associated with these SLEs. Faculty time to develop the case, organize the students, and manage the mannequin; the equipment required to run the simulation; and faculty time for debriefing add up to a very expensive learning experience. It is important to note that sometimes, HFHS are held in simulation centres accessed by multiple health professional programmes (e.g., nursing, anesthesiology, surgery), which creates the potential for cost-sharing initiatives to offset these expenses. Additional studies using a pretest–posttest design to compare high-cost HFHS with lower-cost simulation experiences would enable physiotherapy programmes to undertake more

informed cost–benefit analyses when determining which experiences to include in their entry-level curricula.

MERSQI scores for the studies in this group ranged from 6/18 to 12/18.

Group D: Using simulation to represent clinical education (7 studies)

Two of the articles with the highest MERSQI scores (both 16/18) fell into this category.^{29,30} These were multi-centre randomized controlled trials with large sample sizes that used at least one valid outcome measure and assessed behaviours as well as satisfaction, knowledge, and skill. Each of these studies described two trials comparing models that replaced 25% of clinical immersion time with SLEs in a 4-week internship to a traditional model. The first compared two models: in Model 1, students spent the first week of a 4-week internship in SLE, which included nine cardiorespiratory cases with a HFHS mannequin, followed by 3 weeks of a traditional internship; Model 2 used 50% clinical time and 50% SLE, using the same nine cases and HFHS experiences, for the first 2 weeks of the internship, followed by 2 weeks of a traditional internship.²⁹ Both models were also compared with a control group of traditional clinical immersion. The second study used a similar design, but the cases focused on musculoskeletal diagnoses using SPs.³⁰ Neither study^{29,30} found any differences in the main outcome, the Assessment of Physiotherapy Performance (APP), between traditional clinical immersion and either SLE model, which suggests that structured SLE is a viable substitute for hard-to-find clinical experiences. Secondary outcomes for both studies included students' self-rated confidence in communicating with, assessing, and managing patients. In all cases, students' confidence improved; students who experienced SLE Model 1 rated the SLE slightly lower upon completion of the internship than immediately after the SLE. Outcomes were also collected from clinical educators (CEs) and patients.²⁹ While patients reported that students from both SLE models were comparable, CEs rated 30% or more student groups in SLE Model 1 as not meeting the same standard as their peers in elements of communication, assessment, clinical reasoning, and time management. The students' and CEs' rating of SLE Model 1 may indicate that SLE Model 2 (first 2 weeks 50% SLE, 50% clinical internship, followed by 2 weeks of full clinical internship) was slightly more beneficial, as the students spent at least some time in the clinical environment throughout the 4 weeks.²⁹ The strong, multi-site experimental design and large sample sizes make these studies very robust, and their findings support the hypothesis that SLE can yield similar learning outcomes and replace clinical time, with a slight preference for SLE Model 2. This is incredibly encouraging for faculty responsible for the clinical education components of PT curricula, who are sometimes challenged to find an adequate variety and number of clinical learning experiences.

Two other studies in this group^{23,31} also investigated the effect of SLEs on PT students' performance in the clinical environment. Their two-group pretest–posttest randomized controlled study²³ examined the effect of two 4-hour simulation sessions for the intervention group (compared to the control group, who received no additional pre-clinical training) on self-efficacy scores and APP scores, both evaluated weekly. The researchers found positive significant correlations between self-efficacy scores and APP scores for weeks 2 and 5 for the control group; for the internship group, they found a significant negative correlation between self-efficacy score and week 1 APP score in the area of performing an intervention.²³ They suggest, therefore, that the simulation experience may have contributed to students' overestimating their own performance. A similarly designed study³¹ using the same simulation intervention in the context of cardiorespiratory physiotherapy internships found no improvement in clinical ability for the intervention group relative to the control group. The shorter duration of this simulation experience (8 hours, vs. 1 week in previously discussed studies^{29,30}) may partially explain why the intervention group did not show any additional benefits. In addition, complete data were available for only 20 of the 29 participants in the control group and 10 of 21 participants in the intervention group, which may have affected the results. MERSQI scores for these studies were 16/18 and 14.5/18 respectively.

Three other studies investigated the effects of a mock clinic (a simulated clinical PT department in which students play the roles of patient and therapist) on PT students' experience.^{32–34} The first study³² (MERSQI score 14/18) found that while students in both the traditional clerkship group and the mock clinic group achieved the programme objectives, the mock clinic group scored significantly higher in the interaction component of their practical exam and gave higher satisfaction ratings for the clinical experience. In the second study,³³ one faculty member and a pair of students worked together in a mock pro-bono clinic for a 3-hour session that accounted for 15% of the students' mark for the term;³³ the third study³⁵ described a mock clinic simulation experience for second-, third-, and fourth-year students in which groups of four students alternated role-playing the patient, therapist, and observers, supervised by the Academic Coordinator of Clinical Education. In both of these studies, students reported an improved perceived ability to apply hands-on patient contact skills, less anxiety about their first clinical internship, and appreciation of the opportunity to work on their communication skills and work with the 'total patient,' despite finding this stressful at first. Students also benefited from seeing their faculty supervisor interact with patients, and faculty had the opportunity to be role models for the students and to observe students' clinical performance with patients. This last permitted

earlier identification of areas for improvement, so that faculty could develop a proactive plan before the students' starting their clinical component. Disadvantages of the mock clinic programme included the inherent lack of realism and the need for time-consuming faculty supervision. While these studies illustrate important advantages and disadvantages of mock clinics within PT curricula, the latter two^{33,34} had very low MERSQI scores (7/18 and 4/18 respectively), as both used a one-group posttest design with non-validated outcome measures and assessed the lowest Kirkpatrick level, Reaction (the degree to which participants react favourably to training).³⁵

DISCUSSION

While the majority of studies included in our systematic review had poor MERSQI scores, our findings show that SLEs can benefit PT students by augmenting the learning experience, facilitating skill development and clinical reasoning for the ICU setting, and decreasing anxiety about clinical internships, and that SLEs have the potential to replace up to 25% of a clinical internship. These findings make sense in light of two key education theories: Kolb's experiential learning³⁶ and the challenge point framework.³

Kolb defines learning as "the process whereby knowledge is created through the transformation of experience."^{36(p.38)} According to Kolb's theory, effective learning takes place when a learner cycles through four stages: having an experience (*concrete experience*); having the opportunity to reflect on that experience, either through self-reflection or based on feedback from external sources (*reflective observation*); developing new ideas and relating theory/concepts to the lived experience (*abstract conceptualization*); and, finally, planning and trying out new ideas for future learning experiences (*active experimentation*).³⁶ Guiding learning experiences to allow the learner to cycle through all these stages allows for more effective learning. We can apply Kolb's theory to designing effective simulation practices which ensure that learners pass through each stage: participating in the SLE is the concrete experience; reflective observation occurs as the learner receives feedback (e.g., through a joint-mobilization simulator output or through peer feedback), giving learners the opportunity to go through abstract conceptualization, during which they can debrief and relate theory (potentially content learned in class) and new ideas that surface during the debriefing, which ultimately leads to active experimentation in planning what they could do differently the next time they participate in the SLE. Participating in a simulation experience that allows them to cycle through each stage of learning, giving them the best chance to learn effectively, can theoretically increase learners' confidence and decrease their anxiety. Studies included in our systematic review that allowed learners to cycle through all four stages had positive results; however, incorporating effective learning in designing SLEs is not enough.

Selecting the right simulation experience with the right information at the right time is also critical in ensuring effective learning. The challenge point framework³ explains the relationship among task difficulty, practice, and feedback leading to successful performance. Predicted success in a task is a function of both the difficulty of the task and the level of the performer. Available information arising from the activity can be helpful up to the "optimal challenge point," that is, the optimal amount of potential interpretable information; after this point, however, additional information detracts from performance as well as from the potential learning benefits. Simulation appears to be most effective when it allows for task difficulty to be tied to the level of the learner.⁴ The relationship of task, difficulty, practice, and feedback also informs how practice schedules can affect learning. *Blocked practice* occurs when a learner performs a single skill over and over (e.g., practising a posterior–anterior glide of the third lumbar vertebra for the entire practice session). *Random practice* occurs when learners work on several different skills in combination, randomly working trials and patterns of one and then the next and the next, with each trial interleaved on the previous one (e.g., practising speaking with a patient in the ICU, then transferring the patient to sitting, then interpreting monitors, then monitoring the patient while ambulating). Based on studies summarized by Guadagnoli and Lee,³ blocked practice is most effective for tasks of nominal (average or below average) difficulty and leads to better performance during practice, whereas random practice leads to better immediate and delayed retention, meaning that more actual learning takes place. We noted the same pattern in the studies included in our Group A (simulation studies that focused on learning a specific psychomotor task), which showed limited retention following blocked practice. The lack of skill retention reinforces the fact that these manual skills are difficult to learn and retain, and therefore would benefit from ongoing deliberate random practice for continued refinement. Curricula are often developed around "burst learning"—for example, a course on manual therapy, another course on electrophysical agents—and the concepts taught may not be reinforced until they are encountered in the clinical environment or revisited later in the curriculum. Achieving longer-term retention may require repeated burst practice sessions with the simulators to reinforce learning and potentially enhance retention, followed by practice in the clinical environment with real patients; repetitive practice is a key condition for effective learning.⁶

These educational principles should be applied not only in designing SLEs but also in evaluating educational simulation programmes. Studies incorporating the principles of experiential learning and the challenge point framework with strong methodological designs should lead to better learner outcomes and contribute to the literature on simulation in a meaningful way. Cost-effectiveness

analyses that compare well-designed simulation learning with different levels of fidelity, including implementation costs as well as total costs,³⁷ will provide critical information to help PT programmes make decisions about implementing simulation experiences in entry-to-practice curricula.

LIMITATIONS

Our systematic review has several limitations. First, the list of included studies began with a single author (BM) screening the 820 abstracts that resulted from a comprehensive literature search of five databases. While two authors (BM, JH) participated in two calibration processes applying the inclusion criteria to the abstracts, our review could have been stronger if two authors had reviewed all the abstracts, to minimize any selection bias. Second, the review did not include grey literature sources or non-English-language articles, and as a result may have missed important information that could have added further insight on the topic.

CONCLUSIONS

This systematic review sought to examine the role of simulation activities in entry-to-practice PT curricula. While the studies reviewed included few randomized controlled trials with validated outcome measures, some discoveries about simulation have the potential for positive impact on the design of the PT entry-to-practice curricula. SLEs can be meaningfully incorporated in PT entry-to-practice curricula to improve learners' knowledge, skills, and attitudes. Using simulators to provide specific output feedback to help students learn specific skills (e.g., mobilizations of the lumbar spine) can positively influence their accuracy in delivering those skills. At present, there is little evidence of long-term retention of these skills; future studies should explore a longitudinal approach, whereby students revisit the simulation lab, to determine whether additional exposure has a positive influence on retention. Future studies should also consider the progressive level of simulation fidelity, as described by Brydges and colleagues, to enhance retention and transference of the skills.⁴

Computer-based simulations, such as the Aging Game or virtual recreations of a home environment, can augment students' learning experience; however, future studies should also include a true cost-benefit analysis for developing as well as administering these simulation experiences to inform curriculum development. Human simulation experiences in managing the acute patient in the ICU are also well received by students, positively influencing their confidence and decreasing their anxiety, but are also very expensive learning experiences. Further investigation with pre- and posttest study designs, using validated outcome measures and comparing high- and low-fidelity simulation models, could provide critical information. Lastly, two very strong studies provided

evidence that SLEs can in fact replace 25% of a full-time 4-week clinical rotation, with similar outcomes on a validated outcome measure, and provided slightly stronger support for a model that used 50% clinical time and 50% SLE for 2 weeks followed by 2 weeks of 100% clinical time. Such models could certainly be a viable option for entry-to-practice programmes that are having difficulty in recruiting required internships. Future simulation studies in physical therapy need to consider the full cost of these experiences, and a model for doing so was recently published by Zendejas and colleagues.³⁸ This information is essential for curriculum developers to make informed choices in curriculum design.

KEY MESSAGES

What is already known on this topic

Simulation learning experiences (SLEs) are being implemented in health professional curricula. Simulation can include a range of learning experiences, from using a simulator to represent a patient that demonstrates real-time changes in vital signs, with several invasive and non-invasive monitoring and interventional devices attached (e.g., tracheal ventilation), through to simple simulations of a clinical task, such as paper case studies or simple cardboard box models that replicate surgical procedures. It is important to assess the educational impact of the SLE.

What this study adds

SLEs are generally well received by physiotherapy (PT) students, and have also been found to improve skill attainment and changes in behaviour. Additional investigation with more rigorous study designs need to be conducted to further guide entry-to-practice PT curriculum development.

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